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AIR FORCE MISSILE DEVELOPMENT CENTER

## TECHNICAL REPORT

BEHAVIOR OF THE CHIMPANZEE ON A  
COMPLEX MULTIPLE SCHEDULE

Richard E. Belleville  
Frederick H. Rohles, Jr.  
Marvin E. Grunzke

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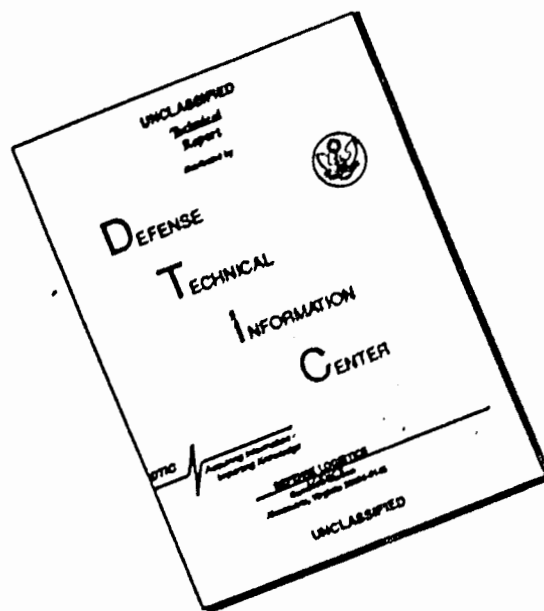
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by

Richard E. Belleville

Frederick H. Rohles, Jr.

Marvin E. Grunzke

Bioastronautics Research Laboratory

Deputy for Development and Test

AIR FORCE MISSILE DEVELOPMENT CENTER  
AIR FORCE SYSTEMS COMMAND  
UNITED STATES AIR FORCE  
Holloman Air Force Base, New Mexico

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## CARE AND HANDLING OF SUBJECTS

The animal experimentation performed in this study was conducted in accordance with the "Rules Regarding Animals" established by the American Psychological Association and the American Medical Association.

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## ABSTRACT

This report describes chimpanzee behavior on a four component, three lever multiple schedule. The component schedules included the Sidman avoidance procedure with a concurrent discriminated avoidance feature on a second lever, fixed ratio performance for food, differential reinforcement of low rate for water requiring a dual response chain, and a symbol discrimination task for continuous food reinforcement using three levers. The advantages of employing this type of schedule for evaluating the effects of exposure to space flight conditions are discussed.

## PUBLICATION REVIEW

This Technical Report has been reviewed and is approved for publication.

FOR THE COMMANDER



FELIX H. JONES, JR.  
Colonel, USAF  
Deputy for Development and Test

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# BEHAVIOR OF THE CHIMPANZEE ON A COMPLEX MULTIPLE SCHEDULE

## I. INTRODUCTION

In the experimental analysis of behavior, a schedule of reinforcement (Ref. 1) refers to the program for presenting rewards when specific responses are emitted. The stimulus conditions existing at the moment of reinforcement, including both physical stimuli and the stimulus consequences of the behavior itself, become the occasion for responding when these conditions are repeated. By manipulating schedules of reinforcement and their correlated stimuli, a wide variety of behavior can be produced.

In a multiple schedule, rewards are programmed by two or more schedules which are presented one at a time, often in a repeating series with each schedule accompanied by a discriminative stimulus (Ref. 1). The advantages as well as possible disadvantages of employing multiple schedules have been discussed by other investigators (Ref. 2 and 3). Such a schedule allows the sampling of a number of different kinds of behavior in a single subject within a short period of time and in a confined experimental space. The maximum advantage is gained from a multiple schedule when the components include a wide variety of behavior. This is achieved by varying the form of the reinforcer, the conditions of its delivery, and the topography of the response (Ref. 3).

This report describes the behavior of chimpanzees on a multiple schedule designed for measuring the behavioral effects of exposure to conditions likely to be encountered in space flight. The schedule consists of four different components with a time-out period ( $S^{\Delta}$ ) interposed between each. Table I presents the component schedules, the characteristics and location of their



TABLE I

Schedule	Stimulus (S <sup>d</sup> ) Lights	Location	Lever	Form of Rein- forcement (rft)	Time in Effect
Sidman avoidance 10 second R-S interval	Red	Right display	Right	Shock White light as secondary rft	10 minutes
Discriminated avoid- ance. S <sup>d</sup> - Shock interval = 5 seconds	Blue	Left display	Left	Shock	2 minute fixed inter- val pre- sentations
Time Out (S <sup>Δ</sup> )	None (dark)	-----	-----	-----	2 minutes
Differential rft of low response rate (20 second)	Green	Right display	Right	Green light on water dispenser	10 minutes
Consummatory drinking response	Green	On water dispenser	Lip lever on water dispenser	Water	Response dependant
S <sup>Δ</sup>	None	-----	-----	-----	2 minutes
Fixed ratio 50/1	Yellow	Center display	Center	Food	10 minutes
Symbol discrimina- tion; continuous reinforcement, 15 second S <sup>Δ</sup> for errors	Odd of 3 symbols	Varied, see Fig. 2	Under odd symbol	Food	18 presen- tations; 10 minute limit
S <sup>Δ</sup>	None	-----	-----	-----	2 minutes
Repeat cycle					

correlated stimuli, the required response topography and lever location, and the form of reinforcer. It also shows the duration and sequence in which the various schedules were in effect.

## II. METHODS

### 1. Subjects

Although informal observations were made on several animals, the data reported are based on one male chimpanzee (No. 64) 3 years of age and weighing 27 pounds. The animal was deprived of food and water for 18 hours prior to each training session and was fed and watered once daily. Food was limited to 800 calories and water was freely available for one-half hour following each training session. Training sessions were approximately 5-1/2 hours long.

### 2. Apparatus

Initial training on the avoidance and DRL schedules was accomplished with the subject seated in a chair and restrained by means of a neck yoke and clamps over both thighs and both ankles. The chair and associated apparatus are shown in Figure 1. Three In-line Digital Displays\* and three levers were mounted in a metal box directly in front of the subject at waist level. The arrangement of displays and levers is shown in Figure 2. The levers were 1 inch in diameter and protruded 2-1/4 inches from the box. Excursion of the lever tip was 2 inches with a 1-inch overtravel.

Each display unit was capable of projecting a red, green, yellow, white, or blue disc of light on a dark 1 by 1-1/4 inch ground glass surface. The display units could also be

\*The In-line Digital Display is manufactured by Industrial Electronic Engineers, Inc., 5528 Vineland Ave., North Hollywood, California.

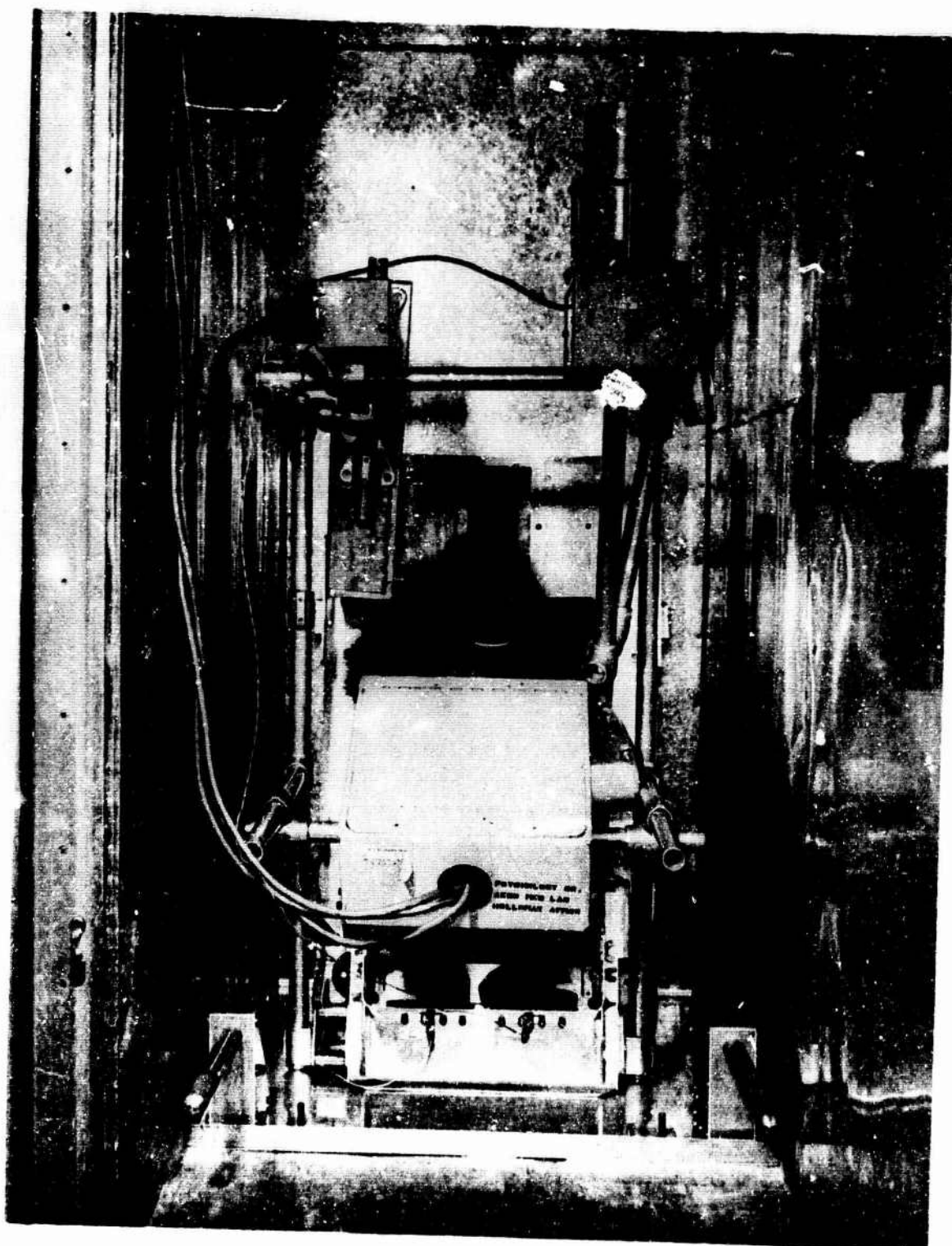


Figure 1. Training Chair and Associated Apparatus with Subject No. 64 Operating Lip Lever

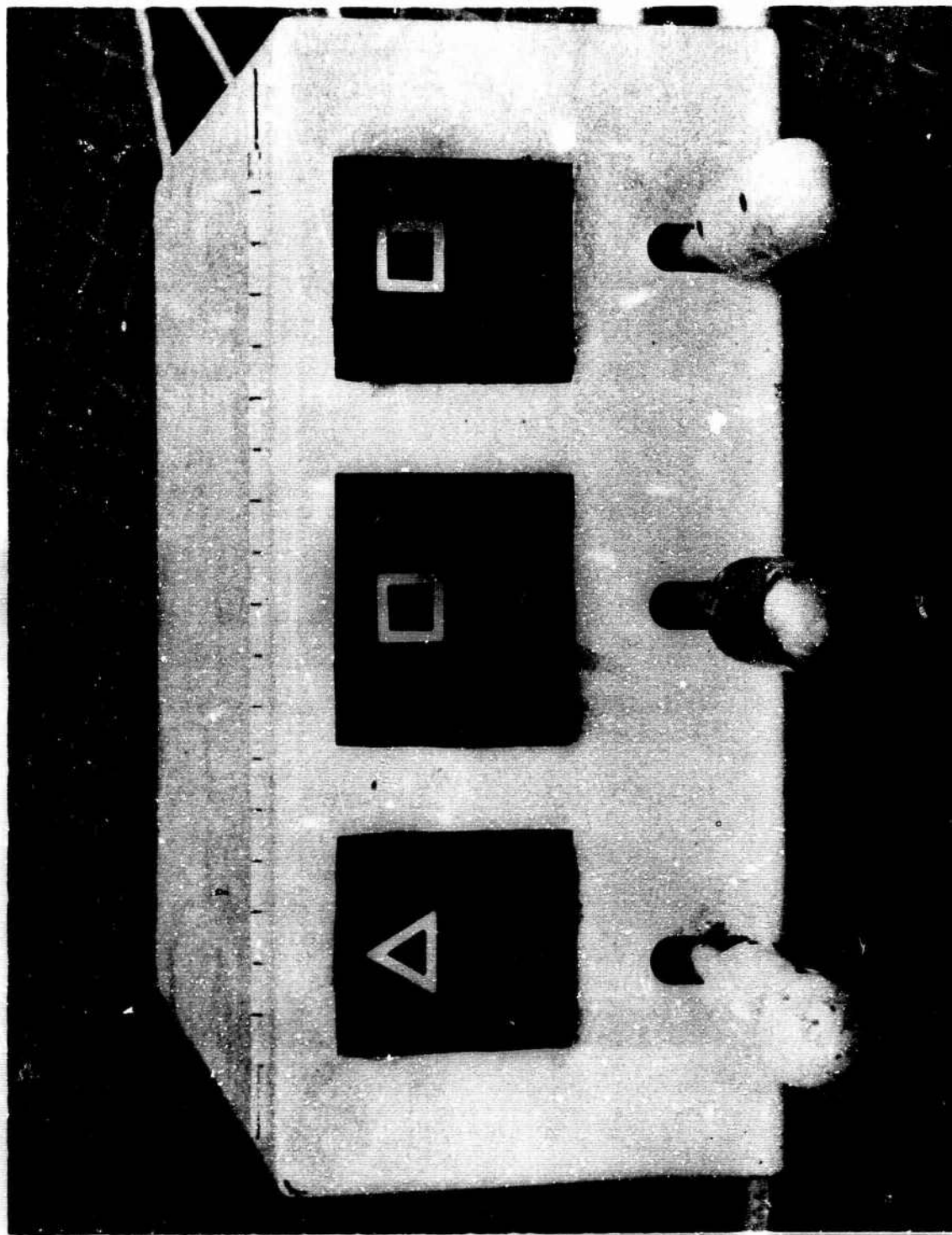


Figure 2. Front Panel of Box Showing Stimulus Displays and Response Levers

programmed to present any of seven white symbols; a circle, triangle, and square were used in this study. Presentation of the colored discs and symbols was accomplished automatically by means of a rotary stepping switch. Programming of events within the various components of the multiple schedule was accomplished by standard operant conditioning equipment.

Reinforcement devices included a Foringer and Company Model 1282 feeder which delivered 1-gram food pellets\* and a liquid dispenser specifically designed for primates (Ref. 4). The appropriate lever response illuminated a light mounted on the water dispenser. A lip lever and drinking tube were mounted just below the light. A measured amount (1 cc) of water was dispensed into the subject's mouth when the lip lever was pressed in the presence of the water light. The arrangement of feeder, hopper, and water dispenser is shown in Figure 1.

For delivery of shock, brass foot pedals, spring hinged to the chair, maintained continuous contact with the feet, yet allowed some movement. A Foringer and Company shock generator was modified by by-passing two 80-megohm resistors. Modal shock values were 12 milliamperes and 100 volts. Shocks were 60 cycle AC and 0.5 second in duration.

Early training on the symbol discrimination task and on the fixed ratio schedule was conducted with the subject in a chamber; a cut-away diagram of this is shown in Figure 3. The arrangement of displays and levers is similar to that shown in Figure 2 except that they were mounted on the wall of the chamber. The chamber was 37 inches long, 29 inches wide, and 51 inches high (interior dimensions) and was illuminated by a 25-watt house-light; an exhaust fan was mounted on top of the chamber.

\* We are indebted to Dr. Dom V. Finocchio, Ciba Pharmaceutical Products, Inc., for providing the pellets.

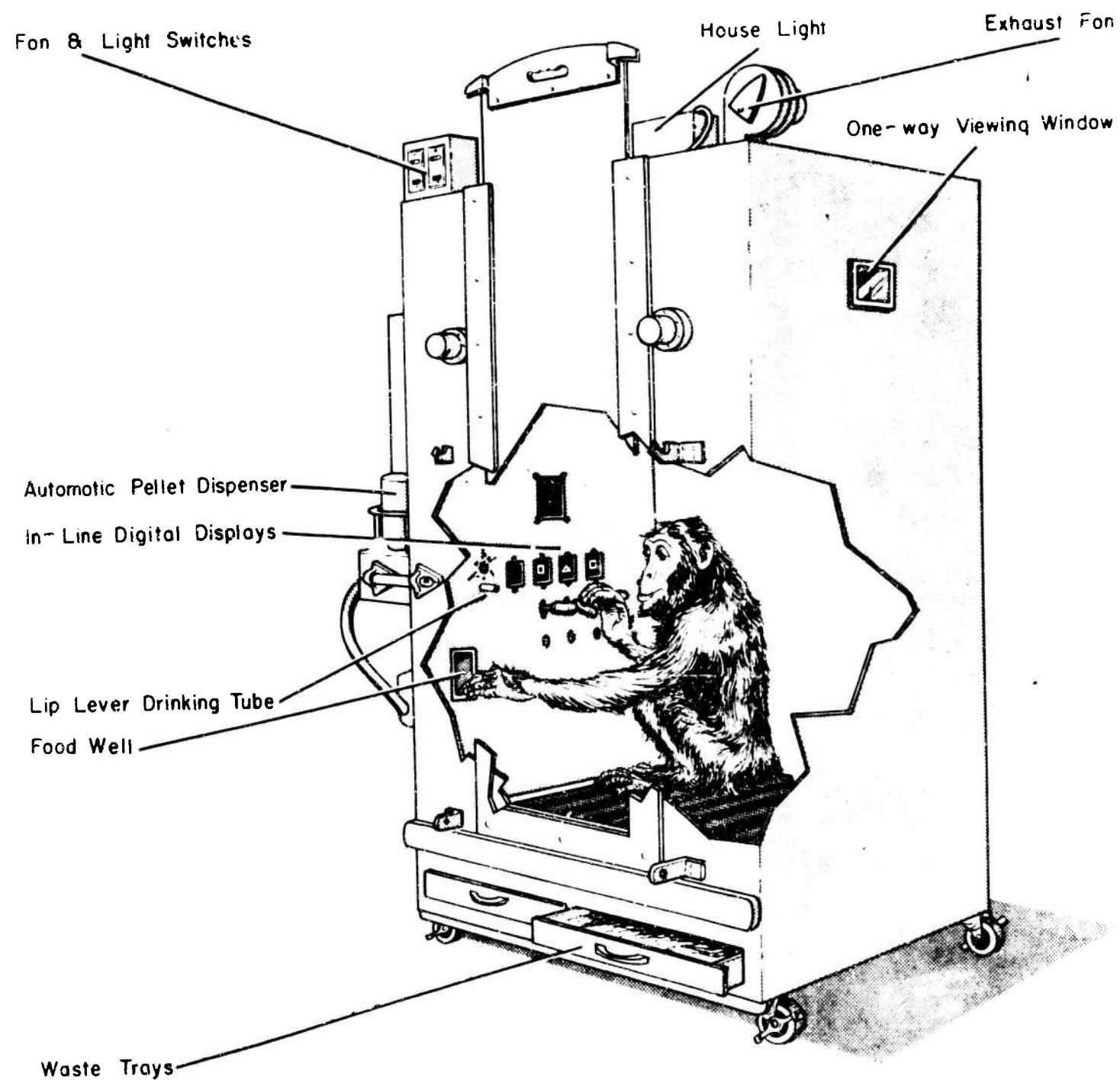


Figure 3. Cut-Away Diagram of Chimpanzee Training Chamber

Presentation of the symbols on the displays was accomplished automatically by means of a stepping switch. Eighteen discrete steps were required in order for each of the three symbols to be "odd" with respect to the other two "like" or "distractor" symbols in all three display positions.

### 3. Procedure

#### a. Avoidance

The avoidance procedure employed here has been described in detail by Sidman (Ref. 5). Briefly, electric shocks are administered to the animal every 2 seconds (the shock-shock or S-S interval) in the absence of lever depressions. Any lever press, however, delays the delivery of shock for a specified period (the response shock or R-S interval). During training, a response shock interval of 20 seconds was used; this was later reduced to 10 seconds. To avoid all shocks the animal was required to respond at least every 10 seconds. A red light ( $S^d$ ) was correlated with the Sidman avoidance procedure. Each lever depression was followed by a 0.3 second flash of white light in the center display.

After this behavior was well established, a discriminated avoidance procedure was introduced using an additional light and lever (Ref. 6 and 7). This required the subject to make a single response on a second (left) lever when a blue light was illuminated. Failure to make this response within 5 seconds resulted in delivery of a shock and termination of the blue light. A response on the left lever turned off the blue light and prevented the occurrence of shock. The blue light was presented every 2 minutes.

#### b. Differential Reinforcement of Low Response Rate

The DRL schedule (Ref. 8 and 9) using a 10-second delay period was introduced using the right-hand lever. The

stimulus correlated with this schedule was a green disc of light on the right display unit. A lever press set the occasion for reinforcement only when 10 seconds or more had elapsed since the preceding response. Responses spaced less than 10 seconds apart, reset a timer and began the timing cycle again. A response made after the 10-second waiting period turned on a light above the liquid feeder. When this light was "on", pressure on the lip lever delivered 1 cc of water. Following an effective response, a new timing cycle did not begin until the lip lever was pressed.

This procedure was preceded by training on the lip lever. The subject was exposed to  $S^\Delta$  periods during which the water feeder light was presented and water was available on a continuous reinforcement basis for lip lever responses. Availability was alternated with  $S^\Delta$  periods during which the water light was "off" and no reinforcement was given.

#### c. Odd Symbol Discrimination

On this component, 18 sets of three symbols appeared consecutively on the display units. Two of the symbols were alike, while the other was different (odd). The symbols, location, and order of presentation are shown in Table II. The response requirement was a single response on the lever under the odd symbol. Details of acquisition of the symbol discrimination task have been reported previously (Ref. 10). For "magazine" training, the subject was placed in the chamber and presented pellets accompanied by a 5-second presentation of a single symbol at 60-second intervals. Following this, the symbol was presented and a lever response under the symbol resulted in food reward. Thereafter, symbols were presented on all three displays as shown in Table II. A response under the display having the odd symbol was reinforced and the next set was presented immediately. An incorrect response (responses



under either of the "like" symbols), was followed by a time-out period of 15 seconds; a response during this period reset the timer in a manner similar to that described for the DRL procedure and the same set of symbols reappeared on the next trial. A correct response was required for each set of symbols before the next set was presented.

TABLE II

STIMULUS SET	SYMBOL ON DISPLAY		
	1	2	3
1	○	△	○
2	△	△	○
3	○	○	□
4	△	○	○
5	△	○	△
6	□	□	△
7	○	□	□
8	△	□	□
9	△	△	□
10	□	○	□
11	□	△	△
12	○	□	○
13	○	○	△
14	○	△	△
15	△	□	△
16	□	○	○
17	□	△	□
18	□	□	○

d. Fixed Ratio

This schedule required the subject to respond 50 times on the center lever in the presence of a yellow light in the center display position. Reward was a 1-gram pellet of food. Early training on this schedule was conducted in the chamber. Following presentation of the 18 oddity problems,

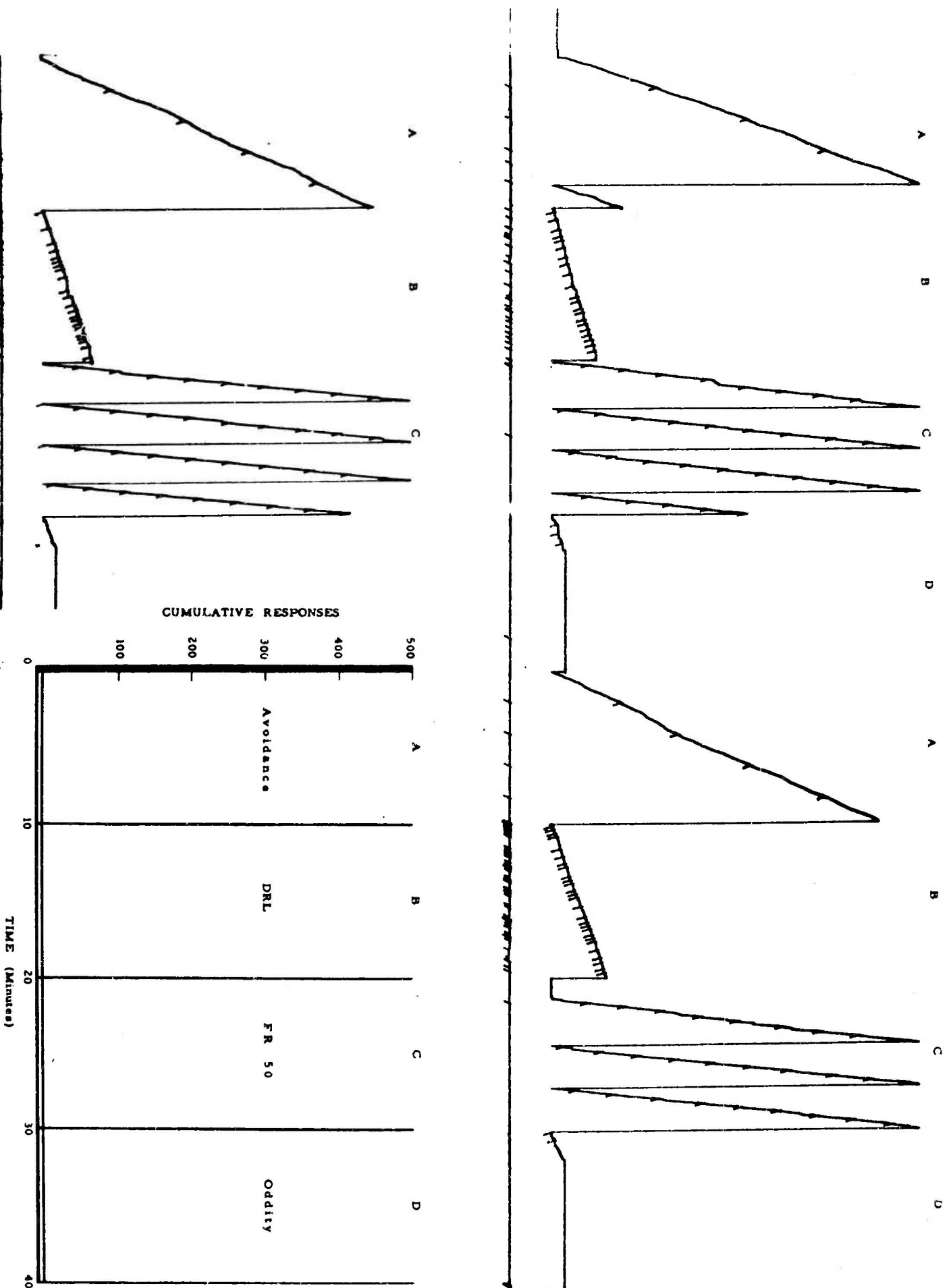
the yellow light was presented for seven reinforcements. The yellow light was thus "odd" with respect to the other two unlighted units so as not to interfere with the odd symbol selection. This served to introduce the ratio performance by providing continuous reinforcement of responses on the center lever. The ratio was gradually increased to FR 50 during chair training periods.

### III. RESULTS AND DISCUSSION

A record obtained from subject No. 64 is presented in Figure 4 which shows three consecutive cycles of performance on the multiple schedule. Responses on the correct lever were recorded in a cumulative fashion as a function of time, with the pen resetting after 500 responses and following each change in schedule. The recorder was stopped during the time out ( $S^{\Delta}$ ) periods between each of the component schedules. Thus, the passage of time in  $S^{\Delta}$  is not shown in Figure 4.

For the avoidance component (A), responses on the right hand lever were cumulated, while responses on the left lever were recorded as deflections on the horizontal line (event pen). Each presentation of the blue light is shown as a diagonal mark on the cumulative curve. Shocks were to be recorded in the same manner, but none occurred. With the DRL procedure (B), the diagonal mark on the curve indicates that the response was made after the proper time lapse and marks on the horizontal event line indicate all lip lever responses. On the fixed ratio schedule (C), diagonal marks indicate reinforcements. For the odd form discrimination (D), correct responses were cumulated, while incorrect responses are shown as diagonal marks. The flat portion of the curve represents time remaining in the 10-minute segment after completion of the 18 oddity discriminations.

Figure 4. Cumulative Record Showing Multiple Schedule Performance



In a previous report, the two avoidance procedures were termed "continuous" for the Sidman schedule and "discrete" for the superimposed avoidance feature (Ref. 6). Further observations suggest that this response sequence becomes chained. During early training, punishment was programmed when responses were made on the left lever when the blue light was not "on". This feature was later eliminated since superfluous responding appeared to be somewhat self-limiting. After initial training, most animals never receive a shock following the blue light presentation which suggests that the left lever response is maintained by the Sidman schedule.

An accurate appraisal of timing behavior on the DRL schedule was not possible, since a distribution of inter-response times was not obtained. The hand lever-lip lever sequence appears to eliminate bursts of responding on the hand lever. Responses following very short intervals are quite frequent on the lip lever and the interval between the hand and lip response is usually quite short.

On the ratio component, pausing after reinforcement was observed in this animal during early training, but with further exposure to the FR schedule these pauses disappeared and a high rate was maintained throughout the entire 10-minute period of exposure to the FR component. The effect of satiation is seen as a late start, i.e., failure to begin responding when the schedule is in effect. The resemblance of this record to that usually obtained under variable interval reinforcement schedules is attributable to the fact that only one hand was used in operating the lever. Eating was accomplished with the other hand at irregular intervals and occasionally after several pellets were available. The pause after reinforcement characteristic of FR schedules is observed, however, in animals that use both hands to manipulate the lever.

Accuracy of discrimination of odd symbols after prolonged exposure reaches about ninety percent accuracy, a level approximating that achieved in subjects trained only on this task. The cumulative curves are similar to continuous reinforcement on a simple operant response and the performance is highly variable and sensitive to disruption from minor distractions such as noise. Much more stable behavior has been obtained when symbol discrimination was reinforced on a fixed ratio schedule (Ref. 11), and exploratory work on a fixed interval schedule has yielded interesting data on correct and incorrect response frequencies as a function of time in the interval.

In addition to the problem of maintaining independence of behavior in a multiple schedule using a single lever, additional difficulties are introduced when several levers are employed and when all levers are immediately accessible. On the fixed ratio and DRL procedures, no control was exerted over responding on levers other than the correct one. This may invite adventitious reinforcement of response sequences and the development of "superstitious" behavior (Ref. 12). Shortly after the component schedules were assembled, subject No. 64 developed a rapid left lever-center lever sequence on the ratio schedule at a FR 20 value. Preventing the left lever response by removing this lever had no effect on responding when the lever was replaced. However, removal of the left lever and reduction of the ratio to continuous reinforcement, followed by very gradual increases in the ratio effectively eliminated this response sequence. The ratio was not increased to FR 50 until the correct lever was well differentiated.

With the DRL procedure, no such behavior was observed. In this case, the effect of incorrect lever responses appeared to produce better lever differentiation. Informal observations

showed that responding on a wrong lever initiates another "waiting" period although this was not explicitly programmed. For all schedules, discrimination of the visual stimuli progressed much more rapidly than did lever differentiation. The sharp contrast between response rates on each of the schedules, and the absence of responses in  $S^{\Delta}$  and on inactive levers, illustrates the high degree of both stimulus discrimination and response differentiation finally achieved. There are, of course, many possibilities for interaction between components, as well as the response sequences within components. Both will require further experimental analysis.

In assembling the multiple schedule described here, an attempt was made to include, so far as possible, different forms of behavior, motivations, response manipulanda and topography, and different controlling and reinforcing stimuli. Such an approach makes possible more accurate inferences regarding both specific and non-specific effects (Ref. 13) as well as possible patterns of effects of the conditions encountered during space flight, in that each variable serves as a control for other changes.

With the present limitation to single subject participation in space flight experiments, an ideal multiple schedule would include an even wider range of experimental operations and their various combinations. Such a completely balanced experimental design within a single subject is entirely feasible. The ease with which new behavior may be added to the repertoire of the chimpanzee suggests that its behavioral capacities in both breadth and complexity have not yet been approached.

## REFERENCES

1. Ferster, C.B. and B.F. Skinner, "Schedules of Reinforcement", New York, Appleton-Century-Crofts, 1957.
2. Morse, W.H. and R.J. Herrnstein, "Effects of Drugs on Characteristics of Behavior Maintained by Complex Schedules of Intermittent Reinforcement", Ann. N. Y. Acad. Sci., 1956, 65: 303-317.
3. Herrnstein, R.J. and J.V. Brady, "Interaction Among Components of a Multiple Schedule", J. Exp. Anal. Behavior. 1958, 1: 293-300.
4. Grunzke, M. E., "A Liquid Reinforcement Device for Primates", J. Exp. Anal. Behav. (In press).
5. Sidman, M., "Avoidance Conditioning with Brief Shocks and No Exteroceptive Warning Signal", Science, 1953, 118: 157-158.
6. Belleville, R. E., F.H. Rohles, M. E. Grunzke, and F.C. Clark, "Complex Avoidance Behavior in the Chimpanzee and its Applicability to the Study of Space Environments", AFMDC Technical Report 60-27, September, 1960.
7. Sidman, M., R. J. Herrnstein, and D.G. Conrad, "Maintenance of Avoidance Behavior of Unavoidance Shocks", J. Comp. Physiol. Psychol., 1957, 50: 553-557.
8. Wilson, M. P. and F.S. Keller, "On the Selective Reinforcement of Spaced Responses", J. Comp. Physiol. Psychol., 1953, 46: 190-193.
9. Sidman, M., "Time Discrimination and Behavioral Interaction in a Free Operant Situation", J. Comp. Physiol. Psychol., 1956, 49: 469-473.
10. Rohles, F.H., R. E. Belleville, and M. E. Grunzke, "The Measurement of Concept Formation in the Chimpanzee and its Relevance to the Study of Behavior in Space Environments", AFMDC Technical Report 60-20, July, 1960, Aerospace Med. (In press).

11. Rohles, F.H., "A Theory Concerning the Development of an Instrumental Sequence in the Chimpanzee", AFMDC Technical Report 61-4, March 1961.
12. Skinner, B. F., "The Behavior of Organisms", New York: Appleton Century Co., 1938.
13. Sidman, M., "Behavioral Pharmacology", Psychopharmacologia, 1959, 1: 1-19.